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2,188,964

IMAGE-FREQUENCY SUPPRESSION SYSTEM

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Fig. 1,

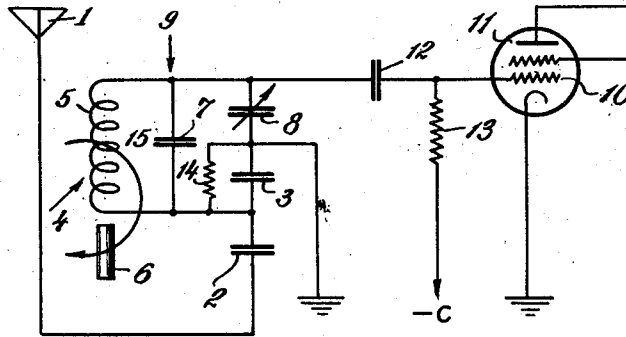


Fig. 2.

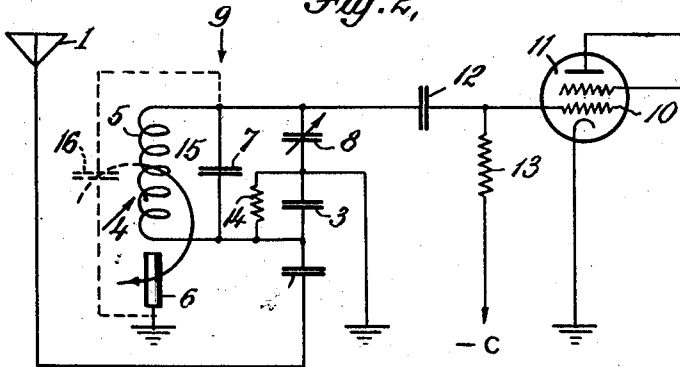
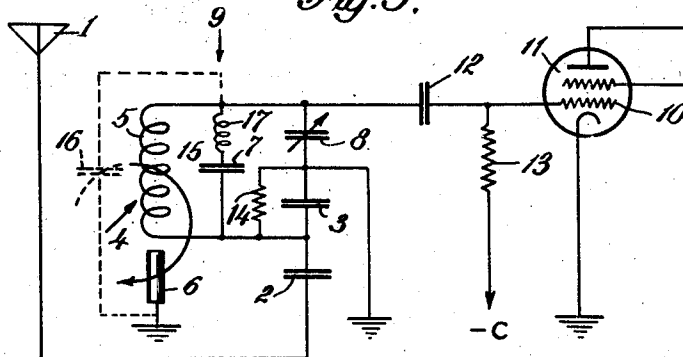


Fig. 3.



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IMAGE-FREQUENCY SUPPRESSION SYSTEM

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8 Claims. (Cl. 250—20)

This invention relates to high-frequency circuits and more particularly to those employed in radio receiving systems of the superheterodyne type, where the signal passes through one or more resonant circuits tuned to the signal frequency, is modulated with locally produced oscillations, then is demodulated and amplified at an intermediate frequency, and finally is demodulated again and rendered audible. The part of the system through which the signal passes before any change in frequency occurs usually includes an antenna circuit and one or two resonant circuits with or without a thermionic amplifying vacuum tube, and may be termed the preselector.

The adjacent-channel selectivity obtainable in a superheterodyne system is largely due to the efficiency of the intermediate-frequency amplifier which, being operated at a fixed frequency, may be designed to have a desired selectivity characteristic. The preselector of the receiving system serves to collect the desired signal, to aid in the rejection of undesired signals in adjacent channels, and to substantially reject signals of certain other frequencies to which a superheterodyne receiver tends to respond.

When the usual superheterodyne radio receiver is tuned to a desired signal, some response is likely to be obtained from a second signal which differs from the frequency of the desired signal by twice the intermediate frequency of the receiver. The undesired signal may be called an image-frequency signal. For example, if the desired signal has a frequency of 600 kilocycles and the intermediate frequency of the receiver is 465 kilocycles, a signal having a frequency of $600 + (2 \times 465)$ or 1530 kilocycles will be an image-frequency signal. The ratio of the input voltage of image frequency required to produce a given output, to the signal voltage required for the same output, is called the image-frequency ratio. A feature of the present invention is to substantially raise the value of this ratio by the proper selection and arrangement of the circuit components.

My invention is intended for use in connection with resonant circuits which are tuned over a range of frequencies by inductance variation. Such a system is the one disclosed by Polydoroff in United States Patent No. 1,940,228, in which a resonant circuit having an inductance coil and capacitor is adjusted over a range of frequencies by movement of a compressed comminuted ferromagnetic core relative to the inductance coil. This method of tuning is commonly called perme-

ability tuning. An improved form of such a system is disclosed by Schaper in United States Patent No. 2,051,012. Both Polydoroff's original system and Schaper's improved system readily cover an adequate range of frequencies and may easily be ganged to provide multiple unit systems. Permeability tuning is especially adapted for use in the preselector of a superheterodyne radio receiver because its use permits the preselector to be designed so as to provide substantially uniform gain and selectivity throughout the frequency range, thus overcoming the chief cause of non-uniformity of performance in this type of receiver.

Although my invention may be advantageously employed in superheterodyne radio receivers having more than one variably tuned resonant circuit ahead of the first demodulator, its efficiency is such that excellent performance is realized from the use of a single variably tuned resonant circuit in this portion of the receiver, thus providing a substantial reduction in the cost of manufacture.

One of the objects of my invention, therefore, is to provide a simple, inexpensive, and efficient system of preselection. A further object of my invention is to substantially improve the image-frequency ratio of a superheterodyne radio receiver. These and other objects are accomplished in the manner to be described below.

In accordance with my invention, image-frequency interference is minimized by providing a high-impedance path or trap circuit for image-frequency signals between the antenna or other collector and the input electrode of the first vacuum tube of the receiver. Since the preselector is tunable over a range of frequencies, the image-frequency trap circuit must also be tuned over a different but properly related range of frequencies, and this must be accomplished automatically and simultaneously.

In the superheterodyne type of receiver, the intermediate frequency is usually lower than the lowest desired signal frequency, and the local oscillator frequency must differ from the resonant frequency of the preselector by a practically constant amount. The difference is equal to the intermediate frequency, the frequency of the oscillator usually being higher than that of the preselector, so that the oscillator must be tunable over a higher but narrower range of frequencies than that covered by the preselector. The image frequency, which in this case is higher than the signal frequency by twice the intermediate frequency, falls within a range which is

still higher and narrower. For example, if a receiver has an intermediate frequency of 465 kilocycles and is intended for the reception of signals between 540 and 1600 kilocycles, the oscillator being designed to cover a frequency range from 1005 to 2065 kilocycles, the image-frequency trap circuit will function over a range from 1470 to 2530 kilocycles. The corresponding ratios of maximum to minimum frequency are 2.96, 2.06 and 1.72, respectively. In accordance with my invention, movement of a ferromagnetic core with respect to an inductance coil may simultaneously tune one resonant circuit over an approximately three-to-one frequency range and tune a second resonant circuit over a higher but narrower frequency range having a ratio of maximum to minimum frequency of approximately 60 percent that of the first resonant circuit.

The invention will be better understood if reference is made to the accompanying drawing, in which:

Fig. 1 is a schematic diagram of the preselector portion of a radio receiver embodying one form of my invention;

Fig. 2 is a schematic diagram of a modified form of the preselector of Fig. 1; and

Fig. 3 is a schematic diagram of another modification of the preselector of Fig. 1.

Referring to Fig. 1, the antenna 1 is connected to ground through capacitors 2 and 3 in series. Variable inductance device 4, comprising inductance coil 5 and movable ferromagnetic core 6, is shunted by capacitor 7, and by capacitors 8 and 9 in series, to form a resonant circuit 9. The high-potential terminal of resonant circuit 9 is connected to control-grid 10 of vacuum tube 11 by means of capacitor 12. Direct-current bias potential is supplied to control-grid 10 by grid leak 13. Capacitor 3 is shunted by resistor 14 to provide a low-impedance path to ground for disturbing audio-frequency currents induced in antenna 1. In operation, resonant circuit 9 is tuned over a range of frequencies by movement of core 6 relative to coil 5. This circuit may be adjusted to resonance at a desired frequency near the high-frequency end of its tuning range, with core 6 substantially withdrawn from coil 5, by means of adjustable capacitor 8.

Inductance device 4 and capacitor 7 also form a resonant circuit 15 which is tuned, by movement of core 6 relative to coil 5, over a range of frequencies higher than that covered by resonant circuit 9. By properly choosing capacitor 7 with respect to capacitors 8 and 9, resonant circuit 15 may be made to resonate exactly at the image frequency which corresponds with any particular resonant frequency of resonant circuit 9, and to resonate approximately at the image frequency corresponding to other frequencies within the tuning range of resonant circuit 9. An examination of Fig. 1 will show that resonant circuit 15 is effectively in series between antenna 1 and control-grid 10 of vacuum tube 11, so that a high-impedance path is provided for signals of image frequency. Signals of the desired frequency, however, are not appreciably blocked, since resonant circuit 15 has a relatively low impedance at this frequency. It will be understood that capacitor 2 is not essential and may be eliminated if desired.

Referring to Fig. 2 of the drawing, the circuit arrangement is similar to that of Fig. 1 and like components are designated by like reference numerals. Ferromagnetic core 6 in this case has appreciable surface conductivity and is effective-

ly grounded, either conductively or through a low-impedance resistive or capacitive path. The capacitance between the core and the high-potential portion of coil 5 is represented by dotted capacitor 16, the fact that the curved arrow passes through it indicating that its capacitance varies as core 6 moves relatively to coil 5. The increase in capacitance 16 during the latter half of the movement of core 6 as it enters coil 5 accelerates the lowering of the resonant frequency of resonant circuit 9 in such a way that the resonant frequency of resonant circuit 15 remains much closer to the image frequency which corresponds to each position of core 6 with respect to coil 5. Thus in accordance with my invention I utilize the core simultaneously to tune two resonant circuits over two different frequency ranges and to maintain a practically constant frequency difference between their resonant frequencies over a portion of the range of adjustability.

In Figs. 1 and 2, it will be understood that capacitor 7 may be replaced by a predetermined value of distributed capacitance built into inductance coil 5 in the well-known manner. It is one of the features of my invention to thus control and utilize the natural resonant frequency of the inductance coil if desired.

Referring to Fig. 3 of the drawing, the circuit arrangement is similar to that of Fig. 2 with one exception, like components being designated by like reference numerals. Inductor 17 is connected in series with capacitor 7 across inductance coil 5. The presence of inductor 17 lowers the rate of change of the resonant frequency of resonant circuit 15 during the latter half of the movement of core 6 as it is withdrawn from coil 5 in such a manner that it remains much closer to the image frequency which corresponds to each position of core 6 with respect to coil 5. Thus the arrangement of this figure provides a high-impedance path which remains tuned practically to the image frequency throughout the range of adjustability of the preselector.

In one successful embodiment of the invention in accordance with Fig. 3 and intended for use with an intermediate frequency of 465 kilocycles, the following constants are employed:

Capacitor 2 (if used)	250 micromicrofarads	50
Capacitor 3	500 do.	
Inductance coil 5	125 microhenries	
Capacitor 7	22 micromicrofarads	
Capacitor 8	18 do.	
Resistor 14	15,000 ohms	53
Inductor 17	7 microhenries	

The average image-frequency ratio over the signal-frequency range of 540 to 1600 kilocycles with this particular arrangement is approximately 5000.

It will be understood that where in the specification I state that one circuit is "tunable over a narrower range of frequencies" than a second circuit, reference is made to the fact that the ratio of the width of the band to the frequency at its center is less in the case of the first circuit. Where it is stated in the specification that one circuit is "tunable over a higher range of frequencies" than a second circuit, reference is made to the fact that the minimum frequency of the first circuit is higher than the minimum frequency of the second circuit and that the maximum frequency of the first circuit is higher than the maximum frequency of the second circuit.

Having thus described my invention, I claim: 75

1. An image suppression system for a superheterodyne radio receiver having an antenna and a vacuum tube with a control electrode, including a first resonant circuit a portion of which is connected between said control electrode and ground, and a second resonant circuit in series between said antenna and said control electrode, said resonant circuits being tuned by inductance variation respectively to a signal frequency and to the corresponding image frequency.

2. An image suppression system for a superheterodyne radio receiver having an antenna and a vacuum tube with a control electrode, including a first resonant circuit a portion of which is connected between said control electrode and ground, and a second resonant circuit in series between said antenna and said control electrode, said resonant circuits including in common a variable inductance device comprising an inductance coil and a ferromagnetic core movable relatively thereto and being tunable simultaneously over substantially different frequency ranges by motion of said core.

3. An image suppression system for a superheterodyne radio receiver having an antenna and a vacuum tube with a control electrode, including a first resonant circuit a portion of which is connected between said control electrode and ground, and a second resonant circuit in series between said antenna and said control electrode, said resonant circuits including in common a variable inductance device comprising an inductance coil and a ferromagnetic core movable relatively thereto, said resonant circuits being simultaneously tuned by motion of said core respectively to a signal frequency and to the corresponding image frequency.

4. A preselector system for a superheterodyne radio receiver, including a variable inductance device comprising an inductance coil and a movable ferromagnetic core, first and second capacitors connected with said inductance device to secure resonance within a first range of frequencies by movement of said core, and a third capacitor in shunt with said inductance device to secure resonance within a second range of frequencies by movement of said core, said capacitors being so chosen that any frequency of said second range is higher than the corresponding frequency of said first range by a practically constant amount throughout said core movement.

5. A preselector system for a superheterodyne radio receiver, including a variable inductance device comprising an inductance coil and a movable ferromagnetic core, first and second capacitors in series shunted across said inductance device to secure resonance within a first range of frequencies by movement of said core, and a third capacitor in shunt with said inductance de-

vice to secure resonance within a second range of frequencies by movement of said core, said capacitors being so chosen that any frequency of said second range is higher than the corresponding frequency of said first range by a practically constant amount throughout said core movement.

6. In a superheterodyne radio receiving system, an antenna, a vacuum tube having an input electrode, and elements including a variable inductance device comprising an inductance coil and a movable ferromagnetic core, a first resonant circuit including said inductance device and tunable thereby over a first range of frequencies connected between said antenna and ground, and a second resonant circuit including said inductance device and tunable thereby over a second frequency range in series between said antenna and said input electrode, said elements being so proportioned that said resonant circuits are maintained at a practically constant frequency difference during movement of said core.

7. A preselector system for a superheterodyne radio receiver, including a variable inductance device comprising an inductance coil and a movable ferromagnetic core, said core having surface conductivity and being effectively grounded, first and second capacitors associated with said inductance device to secure resonance within a first range of frequencies by movement of said core, and a third capacitor in shunt with said inductance device to secure resonance within a second range of frequencies, said capacitors being so related to the capacitance between said coil and said core that the resonant frequency of said second resonant circuit is higher than that of said first resonant circuit by a substantially constant amount throughout said core movement.

8. A preselector system for a superheterodyne radio receiver, including a variable inductance device comprising a first inductance coil and a movable ferromagnetic core, said core having surface conductivity and being effectively grounded, first and second capacitors associated with said inductance device to secure resonance within a first range of frequencies by movement of said core, and a series-connected second inductance coil and third capacitor in shunt with said inductance device to secure resonance within a second range of frequencies by movement of said core, said capacitors being so related to said second inductance coil and to the capacitance between said first inductance coil and said core that any frequency of said second range is higher than the corresponding frequency of said first range by a substantially constant amount throughout said core movement.

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